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Towards decoding the nature of Dark Matter

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The nature of Dark Matter (DM) remains one of the greatest puzzles in particle physics and cosmology. While overwhelming observational evidence across galactic and cosmological scales confirms its existence, decades of experiments have only verified its gravitational interaction. Key properties of DM – such as its spin, mass, non-gravitational interactions, stabilizing symmetry, number of associated states, and mediating particles linking DM to Standard Model interactions – remain unknown.

To address these challenges, we propose a systematic classification of DM based on DM and mediator multiplets with different spins and weak group charges. Additionally, we introduce a novel class of models – Fermionic Portal Vector Dark Matter (FPVDM) – that extends the Standard Model with an SU(2) dark gauge sector. FPVDM offers important implications for direct and indirect detection experiments, relic density, and collider searches
as well as provides the Gravitational Wave signals from specific regions of the parameter space, where the strong first-order phase transition takes place.

Examples of DM models and their signatures will be discussed, alongside prospects for current and future experiments to test them. This talk will argue that a systematic classification of DM models and their signals provides a robust framework for discovering and identifying Dark Matter in the near future.

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